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Boulder Laboratories

A COMPILATION OF THE PHYSICAL EQUILIBRIA AND RELATED PROPERTIES OF THE HYDROGEN-NITROGEN SYSTEM

BY

D. E. DRAYER AND T. M. FLYNN

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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NATIONAL BUREAU OF STANDARDS

Technical Note

May 1961

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Physical Equilibria and Related Properties

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Hydrogen - Nitrogen System

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Abstract

Published data have been used to calculate K factors for the hydrogen-nitrogen system over the liquid-vapor range of 68.2 to 122.2°K, and 10 to 225 atmospheres. K factors are presented graphically for eleven isotherms within this range.

Published data on the solid-gas and solid-liquid regions are presented separately as composition versus pressure at constant temperature.

A bibliography of 250 references pertaining to the hydrogen-nitrogen system is included.

1. Introduction

1.1 Purpose

Hydrogen gas for liquefaction frequently contains large amounts of other gases. Purification of these various hydrogen sources requires considerable knowledge of the physical equilibria of the systems involved. Many theoretical studies have attempted to explain and predict the non-ideal behavior of these systems with varying degrees of success.

An initial step in the study of physical equilibria logically demands a review of current knowledge. In this, the first of a series, the hydrogen-nitrogen system is examined. The purpose of this paper is to determine what is known about the physical equilibria relationships and to present a thorough compilation of known related data for this system. It is hoped that this paper will thus provide a firm basis for the conduct of related research programs and place in the hands of the design engineer the "best" information now available.

Future publications in this area will be concerned with the physical equilibira of hydrogen and other important components.

1.2 Organization

The information is presented in three principal parts: (1) physical equilibria with major emphasis on vapor-liquid equilibria, (2) properties related to physical equilibria, and (3) a bibliography of references. Some discussion is presented with Part (1). The information of Part (2) is presented in tabular form, including the source of the data. Part (3), the Bibliography, lists the references alphabetically by the first author.

1.3 Scope

The scope of this work is as follows: a thorough literature search, as summarized in NBS Technical Note No. 56, revealed much of the pertinent data; such data were abstracted and presented in the form of K-factor charts and as a bibliography of references for related areas of interest. The lists searched are presented in the above reference and will not be enumerated here. They were, however, brought up to date, July 1960.

1.4 Acknowledgements

The authors especially appreciate the aid of the staff of the Data Center of the National Bureau of Standards Cryogenic Engineering Laboratory, who provided the majority of the original papers for review.

2. Survey of Literature

The literature search revealed six important references for hydrogen-nitrogen vapor-liquid equilibria. There were Akers and Eubanks (4), Gonikberg, et al. (91), Maimoni (166), Ruhemann and Zinn (212), Steckel and Zinn (225), and Verschoyle (236). K-factor charts were prepared from data taken from these references. In all but two cases (4, 166), the data had to be re-interpreted to arrive at K-factors.

Two important sources of solid-gas and solid-liquid data were found. These were Dokoupil et al. (57) and Petit (196). This information is presented separately as charts of concentration versus pressure at constant temperatures.

No related physical data are presented in this report; only the references for such material are listed. Other areas so covered include adsorption, diffusion, purification processes, solubility relationships, density and compressibility data, equations of state, thermodynamic and transport properties, P-V-T data, critical constants, virial coefficients, Beattie-Bridgeman constants, techniques of analyses, and various processing references. Such material for the pure components as well as for mixtures of hydrogen and nitrogen is included in many cases.

3. Discussion of Available Data

For this system one could expect the vapor-liquid data, if complete, to range roughly from the triple point temperature of nitrogen to the critical temperature of nitrogen (63.1° to 126.2° K). The references presented in this report provided data for eleven isotherms between 63.2°K to 122.2°K. The isotherms so presented are 63.2°, 68.2°, 78°-79°, 83.3°, 88.2°, 90°, 95°-95.4°, 107.7°, 109°, 113° and 122.2°K. (Rather than take an average temperature

for the 78°-79°, 83°-83.3°, and 95°-95.4°K values, the equilibria data for each narrow range are plotted as one isotherm.) Thus, the data available do present a rather complete picture of the vapor-liquid equilibria for this binary system.

The solid-liquid region has been explored from 20° to 32°K and from 12 to 35 atmospheres. The solid-vapor region has been explored from 25° to 70°K and from 1.3 to 50 atmospheres.

The P-T region covered by published data is presented in Figure 1. This figure indicates that this system has been rather thoroughly explored by the several investigators. (The data for the hydrogen P-T diagram were taken from Johnson (122) and from Woolley, Scott and Brickwedde (248). The data for the nitrogen P-T diagram were also taken from the former reference).

The original data were treated to arrive at the corresponding K-factors. K is defined as y/x where y is the mole fraction of one component in the vapor phase and x is the mole fraction of that component in the condensed phase. K-factors were calculated for each component as a function of pressure and temperature. After plotting the K-factors derived from the various investigators, a smooth curve was drawn for the given isotherm. Finally, the smoothed individual K-factors were transferred to a plot of K versus pressure with temperature as a parameter.

It is not the purpose of this report to present a test of the data for thermodynamic consistency. Maimoni (166) has performed such tests with much of the data herein presented. Maimoni has corrected Verschoyle's data by using new values for the vapor pressure of nitrogen. In this article the original data of Verschoyle are given. As pointed out also by Maimoni, the data of Ruhemann and Zinn differ appreciably from other published values.

Of the data analyzed, the K-factor at the lower pressures showed the most scatter. This was true primarily for the hydrogen K-factor; less scatter was noted for the nitrogen K-factor. Undoubtedly this stems partly from the analytical techniques used.

It must be emphasized that this report is based entirely on the original data of the investigators. These data, in some cases, have not been tested for thermodynamic consistency, and should be used only with thorough awareness of this fact.

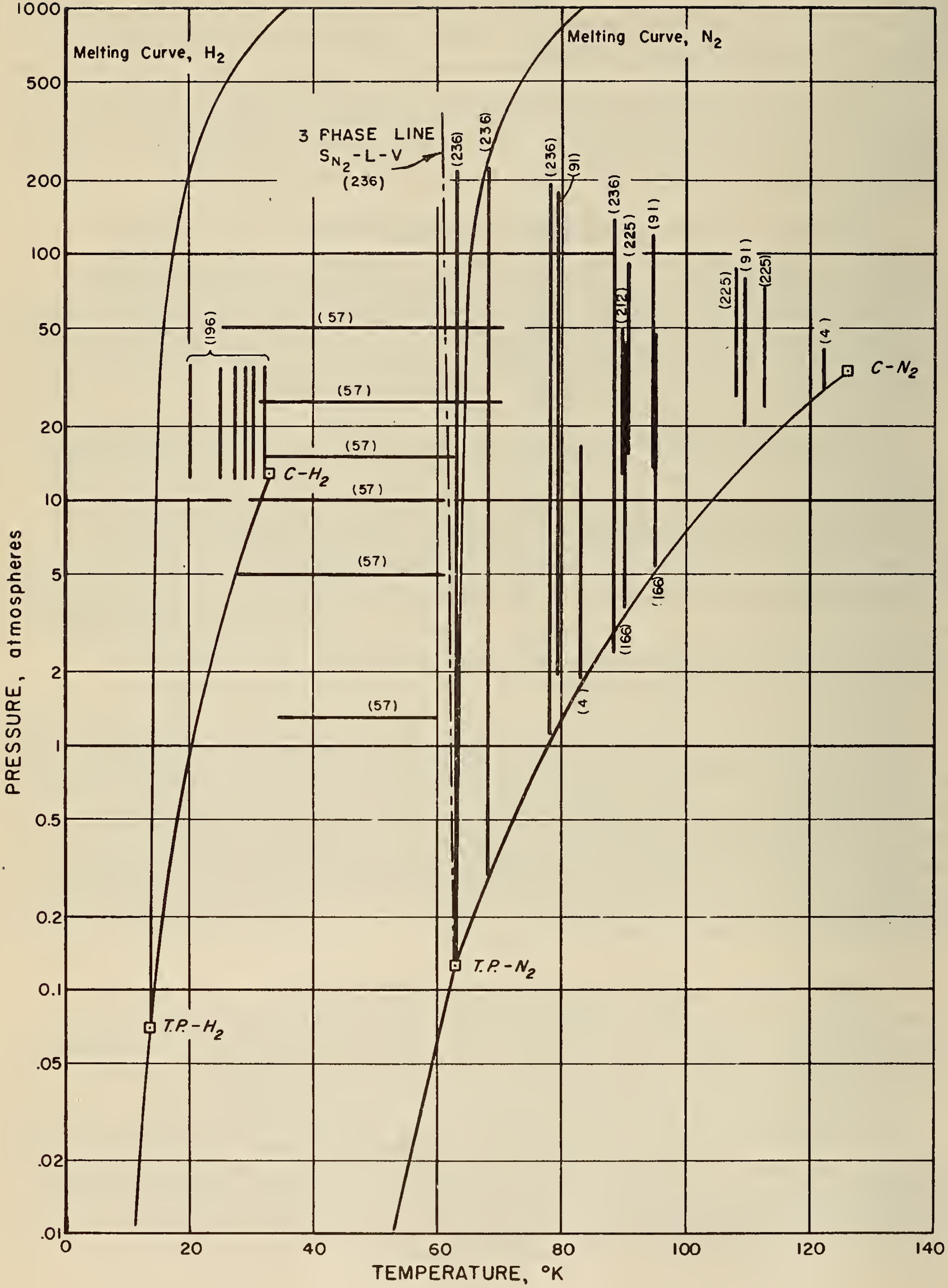

Figure 1. Regions Covered by Published Data

4. K-Factor Charts

Presented in Tables I through VII in the Appendix are the data used in computing K-factors.

Figures 2 and 3 are plots of the K-factors of hydrogen and nitrogen, respectively. Dotted portions on these figures indicate extrapolated areas. (These extrapolations were performed mainly by the original authors.) Figure 4 shows, finally, the curves for both hydrogen and nitrogen as taken from Figures 2 and 3. In Figure 4, hydrogen K-factors are situated above the line K = 1, and nitrogen K-factors are below this line. The significance of the fact that the two curves meet at K = 1 is a characteristic of the plait point. (Verschoyle discusses the plait point.) Thus, the line K = 1 represents a locus of the plait points. The plait point for the 68.2°K isotherm, not shown in Figure 4, was estimated by Verschoyle to be at 340 atmospheres.

The use of these charts might be as follows: for a given system pressure and temperature, K-factors could be read from Figure 4 and the phase compositions found by the following equations.

$$K_1 = y_1/x_1 \tag{1}$$

$$K_2 = y_2/x_2 \tag{2}$$

$$x_1 + x_2 = 1.0 \tag{3}$$

$$y_1 + y_2 = 1.0 \tag{4}$$

where the subscripts 1 and 2 refer to hydrogen and nitrogen. As an example, one might wish to calculate the phase compositions at 88.2°K and 100 atm. Here

$$K_{H_2} = 3.14 = (y/x)_{H_2} \quad ; \quad y_{H_2} = 3.14\, x_{H_2}$$

$$K_{N_2} = 0.235 = (y/x)_{N_2} \quad ; \quad y_{N_2} = 0.235 x_{N_2}$$

Solving equations (3) and (4) for the phase composition gives

$$y_{H_3} = 0.827 \qquad\qquad x_{H_2} = 0.263$$

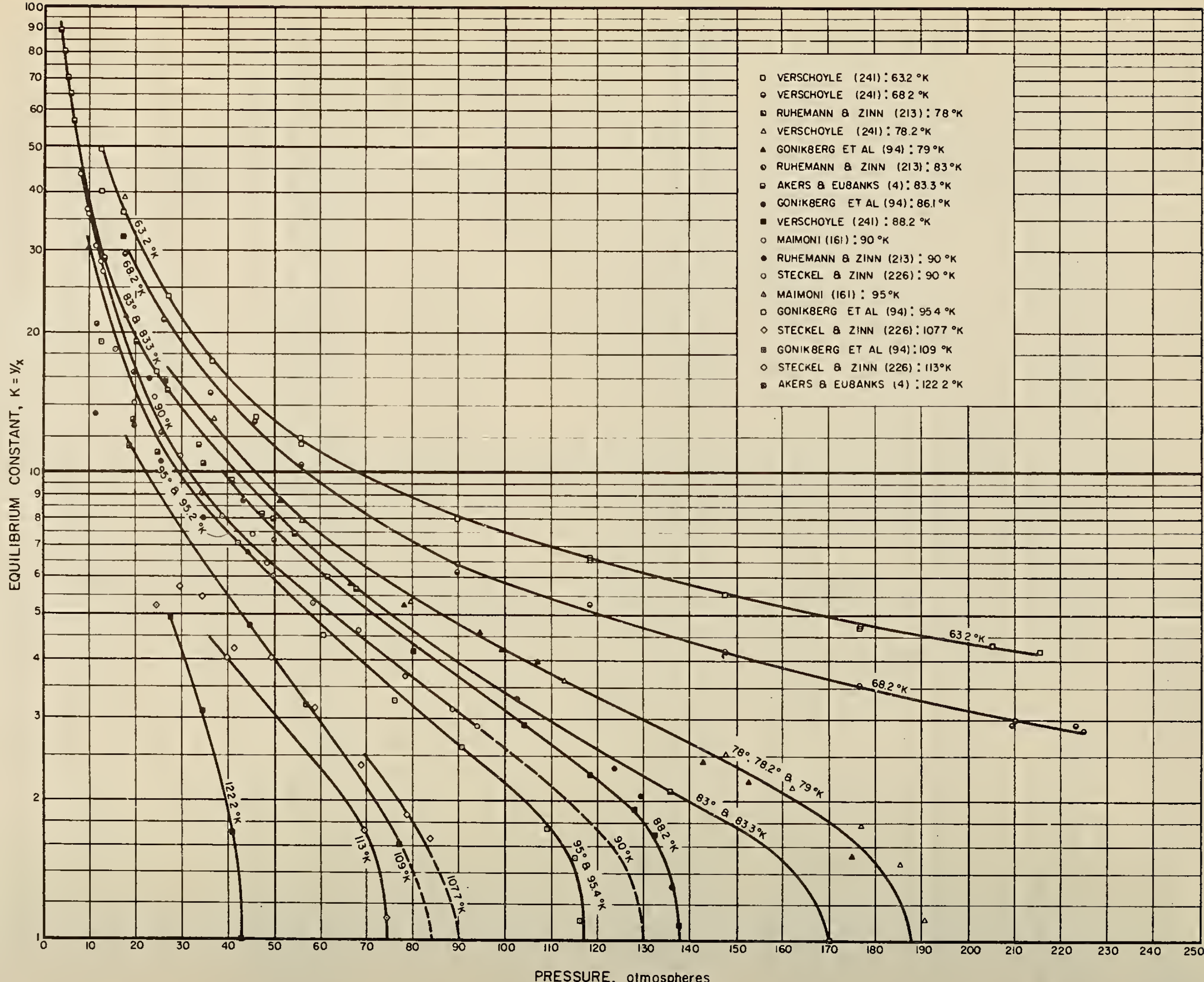

Figure 2. Hydrogen-Nitrogen Vapor-Liquid Equilibria Data. Hydrogen K-Factors

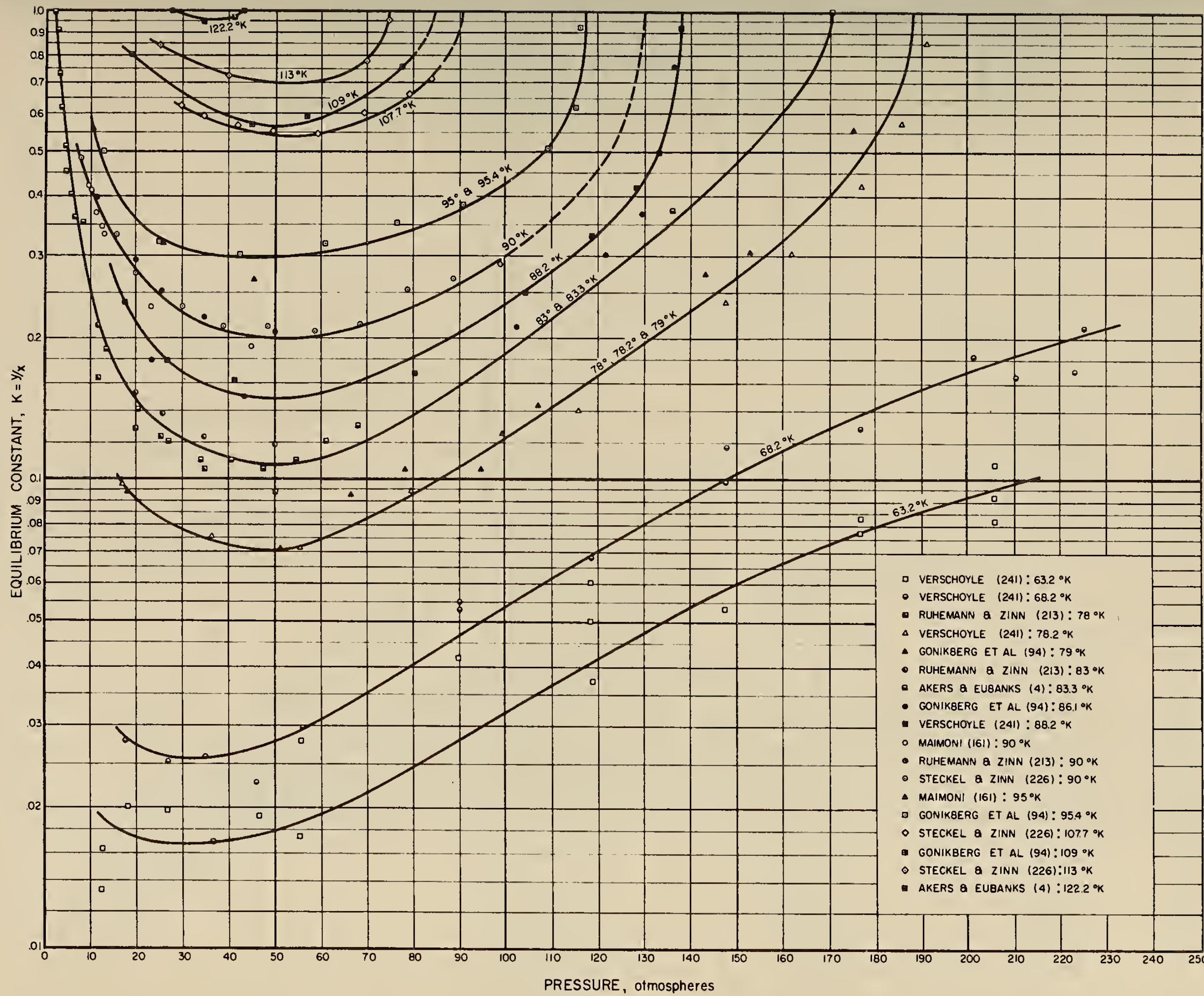

Figure 3. Hydrogen-Nitrogen Vapor-Liquid Equilibria Data. Nitrogen K-Factors

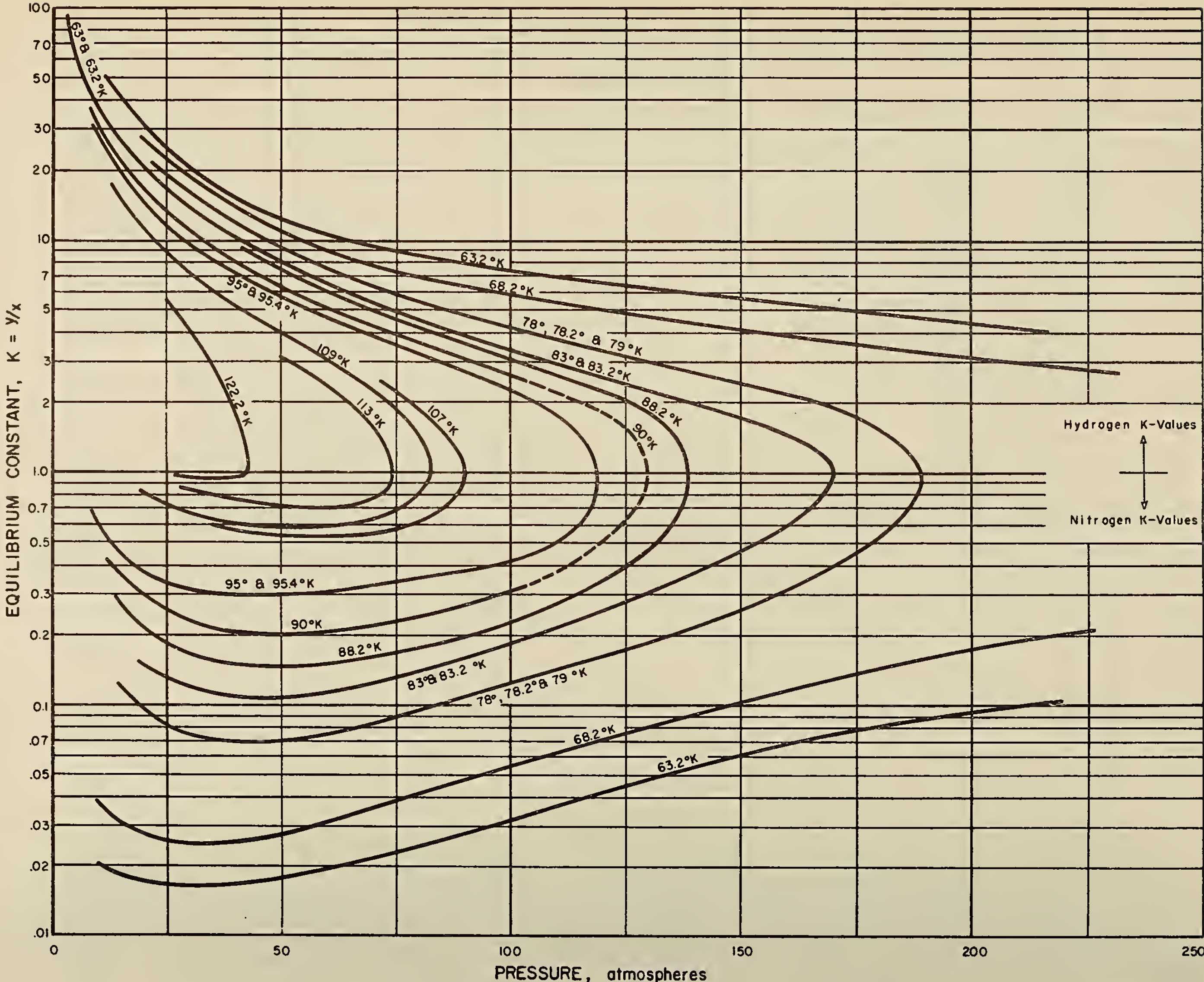

Figure 4. Vapor-Liquid Equilibria. Hydrogen-Nitrogen System

$y_{N_2} = 0.173$ $\qquad$ $x_{N_2} = 0.737$

Similarly, dew points and bubble points of given hydrogen-nitrogen mixtures can be calculated.

The critical constants as derived from the various isotherms are not shown on any of the figures. Verschoyle does comment about the critical points for his isotherms. Table II lists his critical constants.

5. Solid-Liquid Equilibria

Shown in Table VIII are the data of Petit (196). Six isotherms relating liquid phase composition and system pressure are shown in Figure 5.

6. Solid-Gas Equilibria

The data of Dokoupil, Van Soest, and Swenker (57) are given in Table IX. The data have been plotted to derive gas phase composition as related to total pressure for eight isotherms between 25° and 60° K. Table X presents the data in this form. Figure 6 is a plot of the data of Table X.

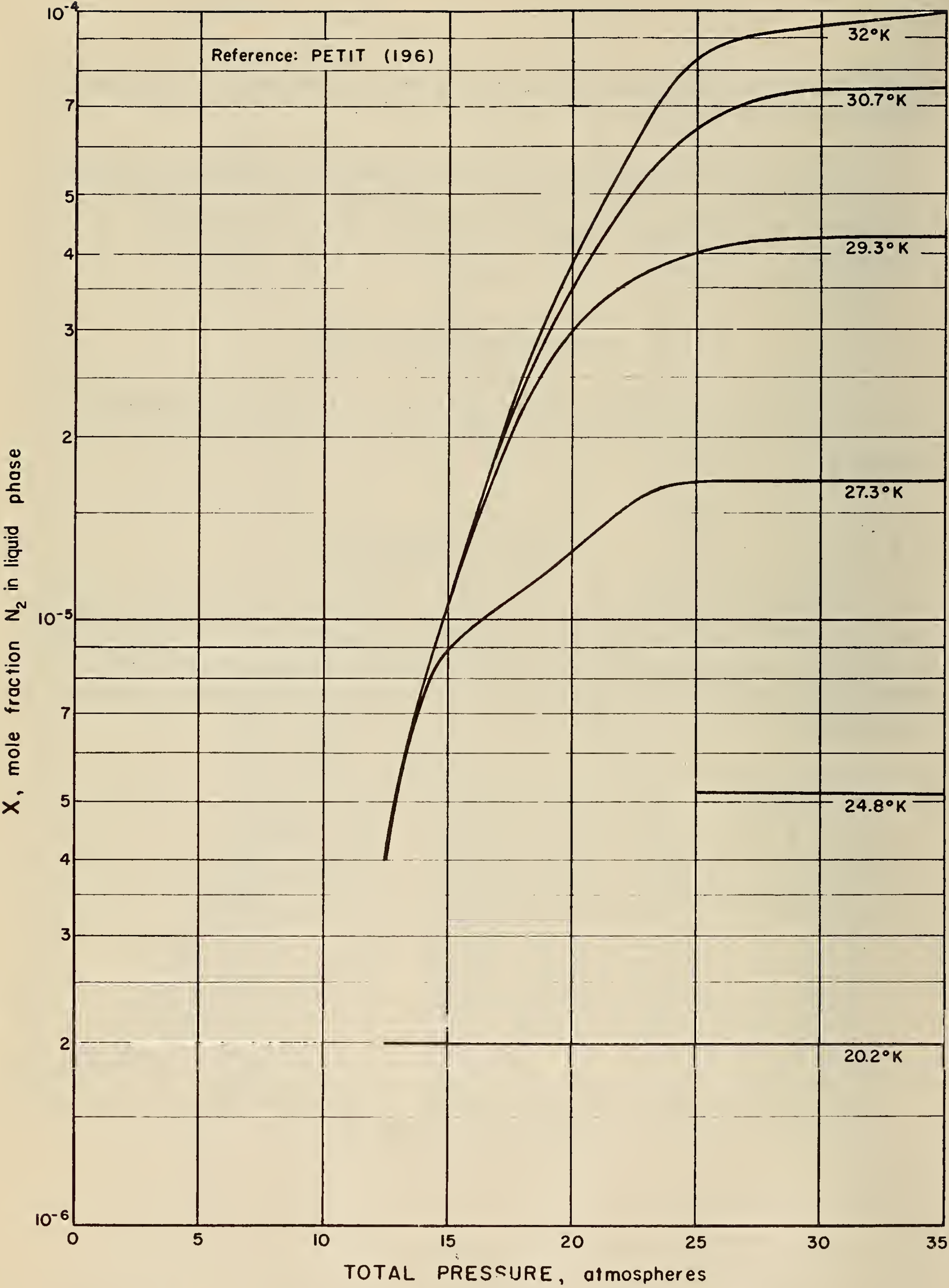

Figure 5. Solid-Liquid Equilibria. Concentration of Nitrogen in the Liquid Phase

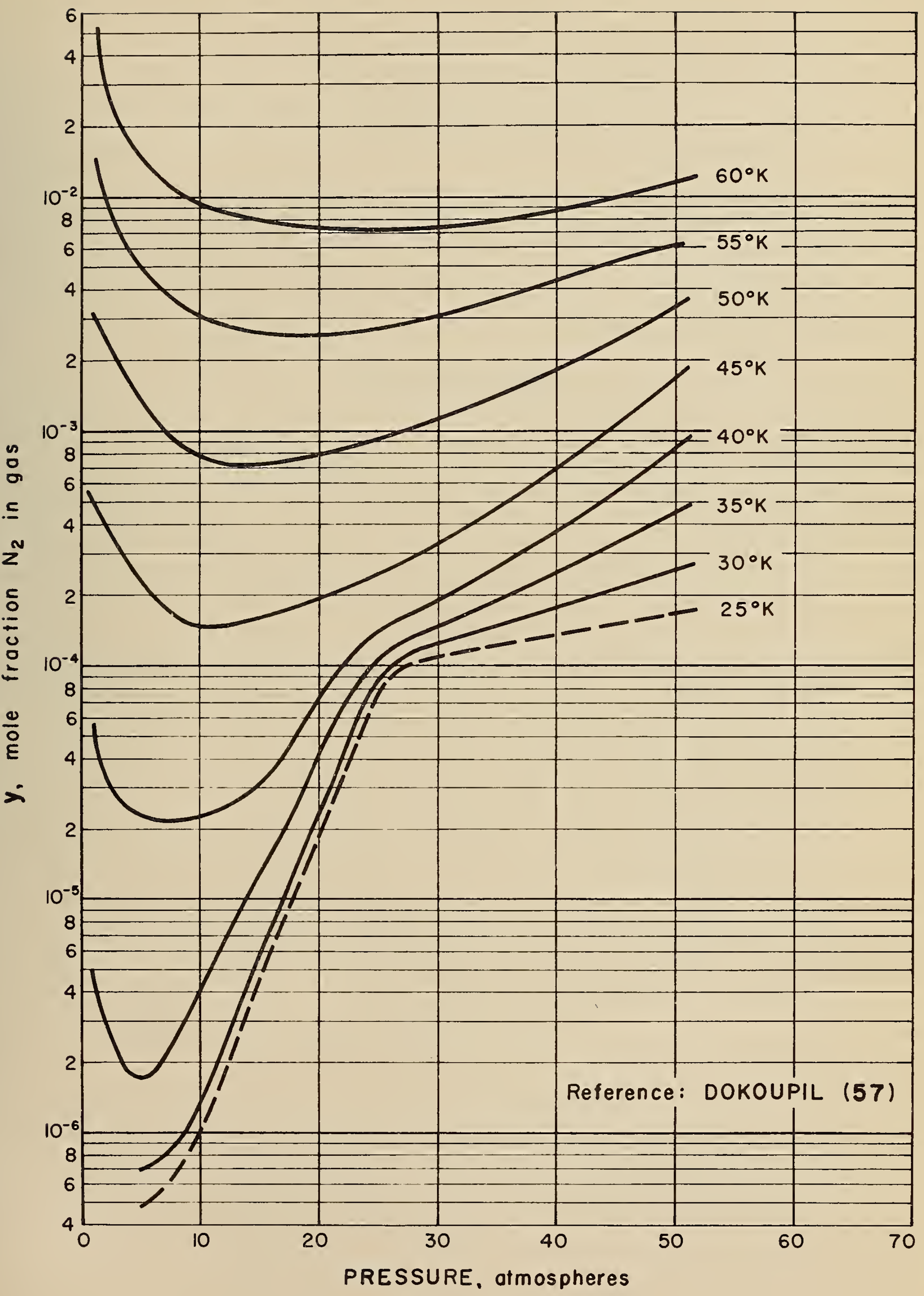

Figure 6. Solid-Vapor Equilibria. Concentration of Nitrogen in the Vapor Phase

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Phenomenon

MAJOR COMPONENT

HYDROGEN

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Phenomenon

MAJOR COMPONENT

NITROGEN

Category	Other Components	References
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Appendix

Table I

N_2-H_2 PRESSURE-CONCENTRATION DATA

Reference: Verschoyle (236)

Temperature		Pressure	Liquid		Vapor		K	
°C	°K	Atm	Mole % H_2	Mole % N_2	Mole % H_2	Mole % N_2	H_2	N_2
-185	88.2	137.73	47.0	53.0	50.8	49.2	1.08	0.928
"	"	132.81	42.0	58.0	71.2	28.8	1.69	0.497
"	"	128.08	38.7	61.3	74.5	25.5	1.92	0.416
"	"	118.34	34.5	65.5	78.3	21.7	2.27	0.331
"	"	104.00	28.3	71.7	82.1	17.9	2.90	0.250
"	"	80.00	20.7	79.3	86.6	13.4	4.18	0.169
"	"	41.04	9.2	90.8	85.3	14.7	9.27	0.162
"	"	26.76	5.3	94.7	83.3	16.7	15.7	0.176
"	"	17.01	2.4	97.6	77.0	23.0	32.1	0.236
-195	78.2	190.89	54.9	45.1	61.7	38.3	1.12	0.849
"	"	185.08	47.9	52.1	70.0	30.0	1.46	0.576
"	"	176.63	43.0	57.0	75.9	24.1	1.76	0.423
"	"	161.88	37.9	62.1	81.3	18.7	2.14	0.301
"	"	147.37	33.4	66.6	84.0	16.0	2.52	0.240
"	"	113.60	24.8	75.2	89.5	10.5	3.61	0.140
"	"	79.90	17.5	82.5	92.2	7.8	5.27	0.0945
"	"	55.56	11.9	88.1	93.7	6.3	7.87	0.0715
"	"	36.59	7.3	92.7	93.0	7.0	12.7	0.0755
"	"	17.19	2.3	97.7	90.5	9.5	39.3	0.0972
-205	68.2	224.81	31.1	68.9	85.4	14.6	2.75	0.212
"	"	222.84	30.7	69.3	88.1	11.9	2.87	0.172
"	"	210.28	29.6	70.4	88.3	11.7	2.98	0.166
"	"	209.28	29.6	70.4	87.0	13.0	2.94	0.185
"	"	176.40	25.2	74.8	90.3	9.7	3.58	0.130
"	"	147.44	22.0	78.0	90.8	9.2	4.13	0.118
"	"	147.41	21.9	78.1	92.2	7.8	4.21	0.100
"	"	118.47	18.1	81.9	94.4	5.6	5.22	0.0684
"	"	89.67	14.7	85.3	95.3	4.7	6.48	0.0551
"	"	89.55	15.4	84.6	95.5	4.5	6.20	0.0532
"	"	55.88	9.4	90.6	97.3	2.7	10.4	0.0298
"	"	45.89	7.6	92.4	97.9	2.1	12.9	0.0227
"	"	35.98	6.6	93.4	97.6	2.4	14.8	0.0257
"	"	26.58	4.6	95.4	97.6	2.4	21.2	0.0252
"	"	17.19	3.3	96.7	97.3	2.7	29.5	0.0279
-210	63.2	215.12	22.2	77.8	92.9	7.1	4.18	0.0913
"	"	205.46	21.6	78.4	93.5	6.5	4.33	0.0829
"	"	205.41	21.0	79.0	91.5	8.5	4.36	0.108
"	"	176.43	18.9	81.1	93.7	6.3	4.96	0.0777
"	"	176.40	19.5	80.5	93.3	6.7	4.79	0.0832
"	"	147.40	17.2	82.8	95.7	4.3	5.56	0.0519
"	"	118.48	14.6	85.4	96.8	3.2	6.63	0.0375
"	"	118.44	14.7	85.3	95.7	4.3	6.51	0.0504
"	"	118.41	14.3	85.7	94.8	5.2	6.63	0.0607
"	"	89.58	12.0	88.0	96.3	3.7	8.02	0.0420
"	"	55.59	8.5	91.5	97.4	2.6	11.5	0.0284
"	"	55.50	8.3	91.7	98.4	1.6	11.9	0.0174
"	"	46.11	7.5	92.5	98.2	1.8	13.1	0.0194
"	"	36.30	5.7	94.3	98.4	1.6	17.3	0.0170
"	"	26.70	4.1	95.9	98.1	1.9	23.9	0.0198
"	"	17.09	2.7	97.3	98.0	2.0	36.3	0.0206
"	"	12.21	2.5	97.5	98.4	1.6	39.4	0.0164
"	"	12.15	2.0	98.0	98.7	1.3	49.4	0.0133

Table II

N_2-H_2 CRITICAL CONSTANTS

Reference: Verschoyle (236)

Temperature		Plait Point		Critical Point of Contact	
°C	°K	Pressure Atm	Mole % H_2	Pressure Atm	Mole % H_2
-185	88.2	138	53	60	87
-195	78.2	191	58	50	93.5
-205	68.2	(340)	--	35	98
-210	63.2	---	--	25	98.5

Table III

N_2-H_2 PRESSURE-CONCENTRATION DATA

Reference: Maimoni (166)

Temperature	Pressure	Liquid		Vapor		K	
°K	Atm	Mole % H_2	Mole % N_2	Mole % H_2	Mole % N_2	H_2	N_2
90	13.38	2.48	97.52	67.32	32.68	27.1	0.335
"	12.80	2.34	97.66	66.19	33.81	28.3	0.346
"	11.69	2.07	97.93	63.67	36.33	30.8	0.371
"	10.07	1.64	98.36	59.03	40.97	36.0	0.417
"	8.32	1.19	98.81	52.17	47.83	43.8	0.484
"	9.93	1.59	98.41	58.55	41.45	36.8	0.421
"	24.09	5.34	94.66	78.00	22.00	14.6	0.232
"	45.34	11.15	88.85	83.04	16.96	7.45	0.191
95	10.94	1.49	98.51	44.92	55.08	30.1	0.559
"	25.87	5.66	94.34	70.05	29.95	12.4	0.317
"	44.72	11.21	88.79	76.43	23.57	6.82	0.265

Table IV

N_2-H_2 PRESSURE-CONCENTRATION DATA

Reference: Gonikberg et al. (91)

Temperature °K	Pressure Atm	Liquid Mole % H_2	Liquid Mole % N_2	Vapor Mole % H_2	Vapor Mole % N_2	K H_2	K N_2
79.0	18.3	4.2	95.8	91.0	9.0	21.7	0.0939
"	51.3	10.7	89.3	93.6	6.4	8.75	0.0717
"	66.8	15.8	84.2	92.2	7.8	5.84	0.0926
"	78.4	17.3	82.7	91.3	8.7	5.28	0.105
"	94.9	19.9	80.1	91.5	8.5	4.60	0.106
"	99.7	21.3	78.7	90.2	9.8	4.23	0.125
"	107.4	22.4	77.6	88.9	11.1	3.97	0.143
"	143.2	33.7	66.3	82.0	18.0	2.43	0.271
"	152.9	36.4	63.6	80.5	19.5	2.21	0.307
"	175.2	45.7	54.3	69.7	30.3	1.53	0.558
86.1	23.3	5.2	94.8	83.0	17.0	16.0	0.179
"	43.6	9.8	90.2	86.5	13.5	8.83	0.150
"	102.6	25.5	74.5	84.1	15.9	3.30	0.213
"	121.9	33.7	66.3	80.1	19.9	2.38	0.300
"	129.7	37.5	62.5	77.0	23.0	2.05	0.368
"	136.5	43.0	57.0	56.6	43.4	1.32	0.761
95.4	13.1	2.7	97.3	51.6	48.4	19.1	0.497
"	24.9	4.2	95.8	69.2	30.8	16.5	0.322
"	42.4	10.2	89.8	73.0	27.0	7.16	0.301
"	61.0	16.2	83.8	73.3	26.7	4.52	0.319
"	76.5	22.1	77.9	72.7	27.3	3.29	0.350
"	91.0	27.7	72.3	72.2	27.8	2.61	0.384
"	109.4	39.4	60.6	69.1	30.9	1.75	0.510
"	115.2	41.7	58.3	63.5	36.5	1.52	0.626
"	116.1	43.2	56.8	47.3	52.7	1.09	0.928
109	19.0	1.8	98.2	20.7	79.3	11.5	0.808
"	44.9	10.3	89.7	48.9	51.1	4.75	0.570
"	57.1	15.6	84.4	50.0	50.0	3.21	0.592
"	77.4	28.4	71.6	45.7	54.3	1.61	0.758

Table V

N_2-H_2 PRESSURE-CONCENTRATION DATA

Reference: Ruhemann and Zinn (212)

Temperature	Pressure	Liquid		Vapor		K	
°K	Atm	Mole % H_2	Mole % N_2	Mole % H_2	Mole % N_2	H_2	N_2
78	11.9	3.1	96.9	84.0	16.0	27.1	0.165
"	20	6.8	93.2	88.1	11.9	13.0	0.128
"	25.2	7.9	92.1	88.6	11.4	11.2	0.124
"	34.8	8.6	91.4	90.3	9.7	10.5	0.106
"	50	11.4	88.6	91.7	8.3	8.04	0.0937
83	11.9	3.8	96.2	79.5	20.5	20.9	0.213
"	20	5.2	94.8	85.5	14.5	16.4	0.153
"	25.8	7.1	92.9	87.2	12.8	12.3	0.138
"	34.8	9.7	90.3	89.0	11.0	9.18	0.122
"	50	12.4	87.6	89.6	10.4	7.23	0.119
90	11.8	4.6	95.4	61.9	38.1	13.5	0.399
"	20	5.7	94.3	72.5	27.5	12.7	0.292
"	25.8	7.2	92.8	76.7	23.3	10.7	0.251
"	34.8	9.9	90.1	80.0	20.0	8.08	0.222
"	50	13.6	86.4	82.2	17.8	6.04	0.206

Table VI

N_2-H_2 PRESSURE-CONCENTRATION DATA

Reference: Steckel and Zinn (225)

Temperature °K	Pressure Atm	Liquid Mole % H_2	Liquid Mole % N_2	Vapor Mole % H_2	Vapor Mole % N_2	K H_2	K N_2
90.0	15.9	67.9	32.1	3.7	96.3	18.4	0.333
"	20	74.0	26.0	5.2	94.8	14.2	0.274
"	30	78.3	21.7	7.2	92.8	10.9	0.234
"	38.9	81.0	19.0	10.0	90.0	8.10	0.211
"	48.7	81.5	18.5	12.6	87.4	6.47	0.212
"	58.7	82.5	17.5	15.6	84.4	5.29	0.207
"	68.7	82.4	17.6	17.7	82.3	4.66	0.214
"	78.8	80.1	19.9	21.7	78.3	3.69	0.254
"	88.8	80.0	20.0	25.3	74.7	3.16	0.268
"	94.3	79.0	21.0	27.3	72.7	2.89	0.289
107.7	29.9	41.9	58.1	7.3	92.7	5.74	0.627
"	34.6	45.3	54.7	8.3	91.7	5.46	0.597
"	41.6	49.2	50.8	11.6	88.4	4.24	0.575
"	49.4	51.5	48.5	12.7	87.3	4.06	0.556
"	59.1	54.8	45.2	17.3	82.7	3.17	0.547
"	69.2	52.8	47.2	22.1	77.9	2.39	0.606
"	79.1	51.8	48.2	27.7	72.3	1.87	0.667
"	84.0	49.9	50.1	30.1	69.9	1.66	0.717
"	(90.9)	(38.9)	(61.1)	(38.9)	(61.1)	(1.00)	(1.00)
113	24.7	18.8	81.2	3.6	96.4	5.22	0.842
"	39.9	33.4	66.6	8.3	91.7	4.02	0.726
"	69.8	39.8	60.2	23.0	77.0	1.73	0.782
"	74.4	35.7	64.3	32.3	67.7	1.11	0.950

Table VII

N_2-H_2 PRESSURE-EQUILIBRIUM CONSTANT DATA

Reference: Akers and Eubanks (4)

Temperature		Pressure	K	
°F	°K	Atm	H_2	N_2
-310	83.3	1.77	---	(1.0)
"	"	2.04	---	(0.9)
"	"	2.72	---	(0.73)
"	"	3.40	---	(0.62)
"	"	4.08	89	(0.51)
"	"	4.76	80	(0.45)
"	"	5.44	70	(0.40)
"	"	6.12	65	(0.36)
"	"	6.80	57	(0.35)
"	"	13.6	20	(0.19)
"	"	20.4	19	(0.14)
"	"	27.2	15	0.12
"	"	34.0	11.5	0.11
"	"	40.8	9.7	0.11
"	"	47.6	8.2	0.105
"	"	54.4	7.4	0.11
"	"	61.2	6.0	0.12
"	"	68.0	5.7	0.13
"	"	136.1	2.1	0.37
"	"	(170.1)	(1.0)	(1.0)
-240	122.2	27.2	4.9	(1.0)
"	"	34.0	3.1	0.94
"	"	40.8	(1.7)	0.97
"	"	(42.5)	(1.0)	(1.0)

Table VIII

SOLUBILITY OF N_2 IN H_2

Reference: Petit (196)

Temperature	Liquid Phase Concentration					
°K	35 Atm.	30 Atm	25 Atm	20 Atm	15 Atm.	12. 5 Atm
	ppm N_2	ppm N_2	ppm N_2	ppm N_2	ppm N_2	ppm N_2
20. 2	2	2	2	2	2	2
24. 8	5. 2	5. 2	5. 2	--	--	--
27. 3	17	17	17	13	9	4
29. 3	43	43	40. 2	30	10. 5	4
30. 7	75. 5	--	65	36. 3	10. 5	4
32	101	95	85	39. 6	10. 5	4

Table IX

GAS-SOLID EQUILIBRIA

Reference: Dokoupil, Van Soest, and Swenker (57)

Hydrogen-Nitrogen Isobar at 50 Atm .		
Temperature °K	Partial Pressure of N_2 mm Hg	Vapor Phase Composition Mole % N_2
70.4	1210	3.18
69.6	1140	3.01
68.6	1080	2.86
64.9	695	1.83
60.2	425	1.12
55.2	250	0.658
55.1	236	0.620
47.2	82.9	0.218
35.1	16.7	0.044
25.1	6.8	0.018
25.1	6.1	0.016
Hydrogen-Nitrogen Isobar at 25 Atm.		
69.4	628	3.30
65.5	330	1.73
65.2	326	1.72
60.3	143	0.753
59.9	137	0.722
59.9	137	0.723
56.4	65.6	0.346
56.2	67.5	0.356
53.4	38.7	0.204
53.4	35.3	0.186
44.3	4.15	0.0219
42.1	3.16	0.0167
38.9	2.50	0.0131
33.2	2.11	0.0111
31.7	1.70	0.00899

Continued

Hydrogen-Nitrogen Isobar at 15 Atm.		
Temperature °K	Partial Pressure of N_2 mm Hg	Vapor Phase Composition Mole % N_2
62.3	133	1.17
60.0	88.6	0.778
59.0	64.6	0.567
57.4	50.4	0.441
55.0	34.0	0.298
50.1	7.40	0.065
43.9	1.26	0.0111
38.0	0.211	0.00185
36.1	0.150	0.00132
34.6	0.125	0.00110
32.1	0.137	0.00120
Hydrogen-Nitrogen Isobar at 10 Atm.		
61.8	102	1.34
60.4	74.3	0.977
58.2	47.3	0.630
56.6	33.6	0.443
54.8	24.0	0.316
50.2	6.15	0.0809
42.2	0.455	0.00558
38.2	0.0848	0.00112
34.7	0.0316	0.000416
31.9	0.0139	0.000183
29.8	0.00900	0.000118
29.6	0.00885	0.000117

Continued

Hydrogen-Nitrogen Isobar at 5 Atm.		
Temperature °K	Partial Pressure of N_2 mm Hg	Vapor Phase Composition Mole % N_2
60.9	71.5	1.88
60.8	63.2	1.67
57.8	34.2	0.902
56.7	26.0	0.685
54.8	18.3	0.482
50.2	5.40	0.142
42.4	0.300	0.00790
38.1	0.0316	0.000832
34.9	0.00625	0.000164
31.6	0.00322	0.0000846
30.2	0.00288	0.0000758
28.0	0.00219	0.0000577
Hydrogen-Nitrogen Isobar at 1.3 Atm.		
60.1	59.5	6.04
59.2	40.0	4.05
58.0	29.0	2.93
49.1	2.08	0.211
45.3	0.530	0.0537
39.1	0.0334	0.00339
35.9	0.00707	0.000717
34.1	0.00198	0.000201

Table X

GAS-SOLID EQUILIBRIA

References: Dokoupil, Van Soest and Swenker (57)

Table IX, this report

Pressure	100 y, Mole Percent N_2 in Gas									
Atm	25°K	30°K	35°K	40°K	45°K	50°K	55°K	60°K	65°K	70°K
1.3	---	---	0.00040	0.0051	0.0470	0.285	1.36	5.10	---	---
5	---	0.000069	0.000172	0.00225	0.0227	0.132	0.490	1.45	---	---
10	---	0.000123	0.000405	0.00220	0.0150	0.0760	0.304	0.930	---	---
15	---	---	0.00122	0.00295	0.0160	0.0720	0.279	0.790	---	---
25	---	0.0090	0.0108	0.0140	0.0248	0.0920	0.272	0.700	1.68	3.54
50	0.0169	0.0255	0.0435	0.0840	0.167	0.329	0.620	1.13	1.93	3.12

U. S. DEPARTMENT OF COMMERCE
Luther H. Hodges, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

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Radio Systems. High Frequency and Very High Frequency Research. Modulation Research. Antenna Research. Navigation Systems. Space Telecommunications.

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